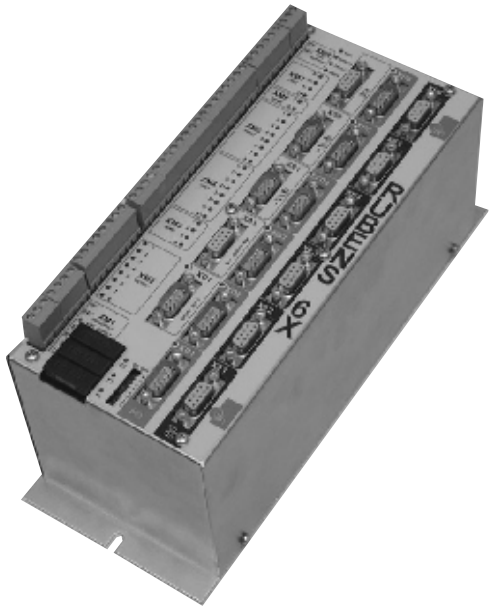
MULTI AXIS MOTION CONTROLLER



Upto 6 axis control.

Linear, circular & tangential interpolation.

Standard ISO G-Code language.

Suitable for stepper or servo motors.

Stand alone or computer operation.

Optional CAD file DXF/HPGL conversion.

Programs downloaded from PC.

Optional mixed servo and stepper control.

The S & H RUBENS controllers are CNC multi axis controllers for automatically controlling machines using stepper or servo motors. They are designed for synchronised motion where two or more axes are run simultaneously. Motion programs are written in ISO (G-Gode) which is easy to use and is familiar to most CNC machine operators. Programs can be written using the 'BACH' PC based software which allows operators to edit and verify programs before downloading them to a controller via the RS232 port.

It is not always necessary to the Windows based S & H software. It is also possible to send the program files as ASCII characters using other software written by the machine manufacturer. Programs can be stored in the controller and executed as required. The controller can be used independently of a PC as programs are stored in a non volatile memory. Typical applications are XYZ profiling tables, pick & place, automatic welding, engraving, packaging machines, glueing & painting.

SPECIFICATIONS

POWER SUPPLY REQUIREMENTS
24 VDC @ 700mA

ENCLOSURE
280mm x 110mm (base) x 180mm high

WEIGHT
2.8kg

OPERATING TEMPERATURE
0 to 40°C

DIGITAL INPUTS
16 off, +12 to +35 VDC
opto isolated
(some required for limit+, limit- and datum inputs)

DIGITAL OUTPUTS
8 off, +12 to +35 VDC @ 300mA
opto isolated

SERIAL PROTOCOL
9600 baud, 8 data bits, ODD parity, 1 stop bit

STEPPER DRIVE SIGNALS
Step, direction, drive enable, drive fault
800kHz max
NPN current sink or 5V TTL

SERVO DRIVE SIGNALS
Velocity, direction, drive enable, drive fault
+/- 10V, 16 bit resolution

ENCODER INPUTS (for steppers or servos)
5V differential (A, A\, B, B\, Z, Z\)
Maximum 4MHz

CONNECTORS
Drives (upto 6): D9 male
Encoders (upto 6): D9 female
Inputs/Outputs: Phoenix screw terminal plugs
RS232: D9 male
CAN BUS: D9 male
Analog input (upto 8): D9 female
Analog outputs (upto 2): D9 male

PROGRAM MEMORY SIZE
200000 characters stored in RUBENS

SH-RUBENS1

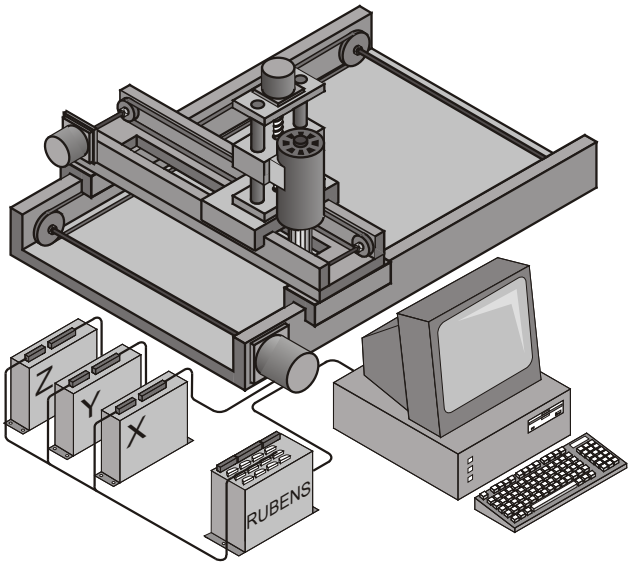
Number of Axes
The RUBENS controllers by S & H are available with 1 to 6 axes of movement.

Power Supply
The RUBENS requires a 24 VDC supply, although this may be between 19 and 35 VDC. The maximum power requirement is 17 Watts and the supply must be smoothed.

Motors
RUBENS versions are available for both stepper and servo motors. For steppers the control output signals are step, drive enable and direction. For servo motors the control outputs are +/-10V velocity demand and drive enable with encoder feedback. Both brushed and brushless servo motors are compatible.

Stepper Drives
There are two main types of stepper drive input. These are voltage inputs and open collector current sink inputs for step, direction and enable. The RUBENS is compatible with both types of drive, including the RTA GMD, GMH, GAC, BCW, SAC, HDG, SDC and MIND drives.

Position Control
Stepper motors are usually run in open loop control (without feedback). However, the RUBENS can be supplied with optional encoder inputs on all axes to close the loop in stepper systems. Servomotors are inherently closed loop so don't require this option.



Inputs
The RUBENS has 16 digital inputs. These are optocoupled and must be switched high to +12 to +35 VDC for logic high. Normally, 24 VDC is used and this may be the same as the 24 VDC supply for the GOYA. These inputs can be read by a motion program. Some of these inputs need to be dedicated to limit and datum switches for all the axes. It is also usual to dedicate one input to an emergency stop.

Speed profiles
The RUBENS has built in ramping and is capable of trapezoidal, parabolic and 'S' type velocity profiles.

Outputs
The RUBENS has 8 digital outputs. These are also optocoupled, switching +24 VDC at upto 300mA. It is permissible to use the same power supply as the RUBENS. These outputs can be switched on and off by the motion program. They can be used to switch on cutter tools, clamps, solenoids, punches etc.

Limits & Datums
Each axis in a machine will require limit and datum switches for each axis (limit-, limit+ and datum). It is usual to use normally closed switches as they are failsafe. Upto eight of the inputs (depending on model) are dedicated to limit switches as follows. Datum switches have dedicated separate inputs.:

Input 9	*Limit +X axis*	Input 13	*Limit + Z axis*
Input 10	*Limit - X axis*	Input 14	*Limit - Z axis*
Input 11	*Limit +Y axis*	Input 15	*Limit + W axis*
Input 12	*Limit - Y axis*	Input 16	*Limit - W axis*

Emergency Stop
When an emergency stop button is hit (a normally closed switch connected to one of the inputs) the drives will all de-energise. The machine cannot be re started until the RUBENS is reset. Normally, an emergency stop safety circuit will also cut off power to the drives and other components that could cause injury.

Interpolation
The RUBENS controllers are capable of linear and circular interpolation. Linear interpolation can occur on upto 6 axes simultaneously (eg, in XYZWPQ space). Circular interpolation can occur on any 2 axes (eg. XY, WZ, YW, PX planes).

Tangential control
Apart from interpolation, the RUBENS can control a knife cutter and maintain its tangent to the path to be cut.

3D Motion
The RUBENS can control motors in 3 dimensional space, but it is not intended for full 3D sculpturing. It is possible to machine a curve in 3 dimensional space by breaking such a curve into small linear segments in XYZ space and running the motors 'point to point', however the programming can be tedious unless it is generated by special CADCAM software.

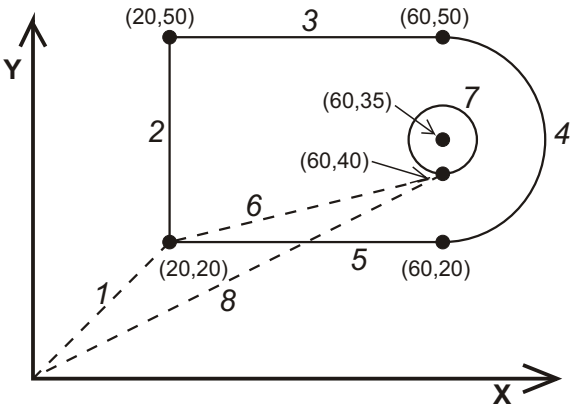
Motor Speeds
Motor speed is determined by the maximum step output frequency of 800kHz for the stepper model RUBENS and the maximum encoder input frequency of 4MHz for the servomotor or stepper & encoder models. For example, if you are using an open loop stepper motor drive with 25000 steps/rev resolution, the maximum motor speed will be 800000/25000 = 32 revs/sec.

Time delay
Time delays (dwell) are useful in machines where motors must wait until a machining operation is complete. This is possible with the ISO G-Code language using the G04 command. Time delays from 0.01 to 9999.99 seconds are possible.

SH-RUBENS2

Programming Language

The motion language is 'ISO' of G-Code which is used on CNC machine tools. Machine operators will be familiar with this and it won't be necessary to use computer programmers to program the controller. The G-Code commands are listed at the end of this brochure. Some commands will not be available in models without interpolation. An example of a G-Code program is shown in the diagram. This could be a router, oxy cutter, laser or plasma cutter.



PATH	CODE	DESCRIPTION
1	G00 X20 Y20 F1000	Goto (20,20) rapidly, speed 1000mm/min
	G00 Z20 F500	Lower Z to 20mm at 500 mm/min
	G68 P1	Turn output 1 ON
2	G01 X20 Y50 F300	Goto (20,50), speed 300mm/min
3	G01 X60 Y50	Goto (60,50) at same speed
4	G02 X60 Y20 I60 J35	Clockwise arc ending (60,20), centre (60,35)
5	G01 X20 Y20	Goto point (20,20), same speed
	G67 P1	Turn output 1 OFF
	G00 Z0 F500	Raise Z axis to 0mm at 500 mm/min
6	G00 X60 Y40 F1000	Goto (60,40) rapidly, speed 1000 mm/min
	G00 Z20 F500	Lower Z to 20mm
	G68 P1	Turn output 1 ON
7	G02 X60 Y40 I60 J35 F300	Arc ending at (60,40), centre (60,35)
	G68 P1	Turn output 1 OFF
	G00 Z0 F500	Raise Z to 0mm at 500 mm/min
8	G00 X0 Y0 F1000	Goto datum 1000 at mm/min

Speed change

Speed is defined by the 'F' command in the program. Overall speeds (all axes) can also be manually changed while the program is still in operation by computer screen.

On the fly speed change

At times it is necessary to change speed of a motor, according to a program, while still in motion and without stopping the motor. This can be achieved by the G57 and G58 auto linkage commands.

P.L.C.

Often, a machine also requires a lot of logic switching and monitoring as well as motor control. The RUBENS can be provided with a P.L.C. option, expandable up to 128 inputs and 128 outputs using CAN bus. The PLC function which is programmed in ladder logic runs independently from the motor control.

Protection

When controlling the RUBENS from a PC, different machine operators can be assigned different passwords depending on competence and level of options available.

Analog Inputs

The RUBENS can be supplied with optional 8 analog inputs, 0-5V, 10 bit and a +5V DC excitation for potentiometers and sensors. These analog inputs can be read by a program.

Analog Outputs

The RUBENS can be supplied with 2 optional analog outputs, +/- 10V, 12 bit. This option is only available with the stepper versions of RUBENS.

Engineering Units

All programming is done in engineering units such as millimeters or inches and not motor revs, steps or encoder pulses.

Precision

Theoretical positions are accurate to 6 decimal places, however, for simplicity, the user can program the desired number of places displayed.

Continuous Execution

Using the G57 and G58 commands, the RUBENS will perform continuous execution of segmented paths. This is essential in cutting applications where a stationary cutting tool will burn the workpiece.

CAM function

The RUBENS can also perform a CAM function. This is to run a motor at a particular velocity profile according to a lookup table of speeds versus distance.

Master/slave

The RUBENS can also run a motor at a programmed speed ratio to a machine, as sensed by an encoder. This can be used to control feed speeds at a ratio to spindle speed for thread cutting.

Variable management

The RUBENS can also perform mathematical operations on variables (eg. obtained from analog inputs). Operators are + - * / ^ and square root.

Housing

The RUBENS is housed in a surface mounting sheet metal case. All connections are on the top of the RUBENS. Although the depth of the case is 160mm, allow at least 230mm for connectors.

Probe

For scanning it is necessary to have a probe input to sense position. This is possible as the RUBENS inputs are high speed. An axis is moved at a defined speed using the G06 command and as soon as the probe is hit, the motor will stop and the position can be read by the RUBENS.

SH-RUBENS3

Wait
When machining, it is sometimes necessary for the RUBENS to wait and not move motors to the next position until it is clear and an input is sensed. This can be done using the G66 'hold input' command.

Loops
If you had to machine a large number of identical items the program would be long. It is possible to write a program for one item and repeat it many times in an array.

Settings
When setting up the RUBENS there are numerous settings such as motor speeds, acceleration rates, input switch logic, scaling factors etc. Once these are programmed and stored in the RUBENS memory, an unauthorised operator will not have access to them.

Subroutines
When run in stand alone mode, the RUBENS can support subroutines (nested to 8 levels) to make program size smaller.

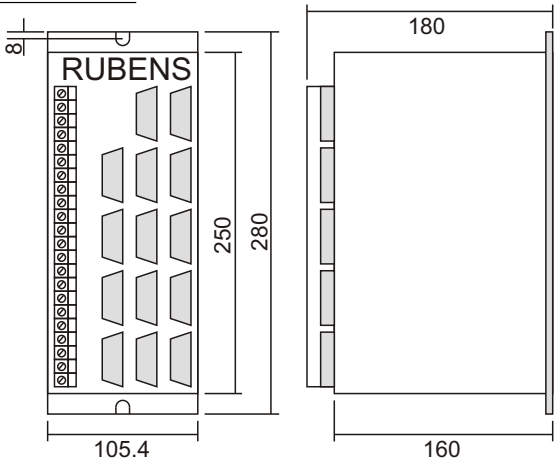
Control
The RUBENS has a serial port, allowing it to be interfaced to a PC running Windows 95 or 98. Using the S & H BACH software, programs are written, saved, edited, graphically verified and then sent to the RUBENS. The dongle protected BACH software is written by the manufacturers of the RUBENS.

There are two modes of operation with the RUBENS. In the first mode, the computer is controlling the machine and motion programs are sent to the RUBENS in packages as the machine is running. This is useful for very large programs where you want to view status on the screen.

In the second mode, motion programs are downloaded into the RUBENS and then saved in a non volatile memory. Then a program can be started using in input switch a a trigger. The computer does not need to be connected for this operation!

The memory in the RUBENS is about 150000 characters. A typical G-Code program line like "G01 X150.0 Y20.0 F300" consists of 21 characters so you could fit 7142 lines of code similar to this. The maximum number of programs is 100.

DIMENSIONS

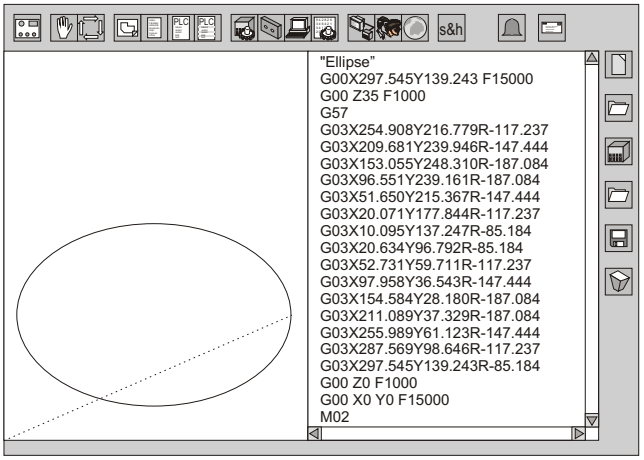


Downloading Software
If you do not wish to use the BACH software to download programs, it is possible to do this yourself. The motion program just consists of ASCII codes and the RUBENS manuals provide all the data transfer commands to send programs through the comms port. This is handy if you have a small number of RUBENS programs that are used repetitively and are rarely changed. However, you will need an experienced computer programmer for these applications.

Programming without Computer
It is possible to edit and enter motion programs into the RUBENS using the keypad and display. This does not require a computer. However, the procedure is not recommended for large programs as it can be very time consuming and has a high error rate.

Manual Jogging
It is possible to manually jog axes on the machine, either when the RUBENS is linked to a computer or running alone. When using BACH, jogging can be done by clicking on an axis icon and pressing arrow keys for continuous motion or moving a set distance at a time. The machine can be datumed by clicking on a datum icon.

BACH Lite
The RUBENS is supplied with BACH Lite software at no cost. This does not allow you to download motion programs. It enables you to set up the RUBENS to the correct machine parameters such as scaling, speeds, accelerations and inputs.



BACH 2000 - PROGRAM EDITING

BACH 2000
This is the full version of BACH and allows you to download programs into the RUBENS and operate the RUBENS from a computer. To use this software a dongle is required.

Computer mouse
When running RUBENS from a computer, functions can be selected using a computer mouse. However, mice do not survive long in a harsh environment so keyboard arrow keys, F10 and return keys can also be used.

SH-RUBENS4

Flexible program files

The programs saved by the BACH software are basic ASCII text files. You don't need special codes to read them. You can read them and edit them on a word processor if you want. You can use other CAM packages to generate the program and read them with the BACH software. You could even write a program with the mathematics to generate the lines of code for small linear segments (such as a 3 dimensional shape) and save the file to a disk. The BACH software is not particularly sensitive about formatting the lines of code but commas and stops cannot be used.

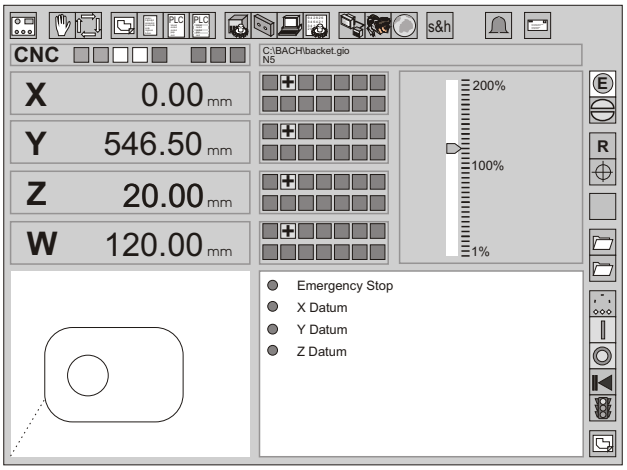
G01 X100 Y50 Z40 F1000 OK
G01X100Y50Z40F1000 OK to omit spaces
N20 G01 X100 Y50 Z40 F1000 Line numbers OK

G01 X100 Y50 OK to omit 'F' command
Controller assumes same F as before

X100 Y50 OK to omit 'G' command
Controller assumes same G as before

g01 X 100 Y 50 Z 40 F 10 00 Not acceptable
No spaces or lower case

G01,X100,Y50,Z40,F1000 Not acceptable
No commas allowed.



BACH 2000 - MACHINE CONTROL

Terminal Mode

When running the RUBENS from a computer and when first testing a system, it is useful to be able to send single lines of G-Code to the RUBENS. This can be done by the terminal mode that lets you type a single line and download it by pressing return.

Teach mode

When using the BACH software, complex shapes can be programmed by manually jogging motors to point positions and clicking enter which automatically generates a line of code in the program. This is useful when programming shapes that are not easily mathematically defined and where accuracy is not critical.

Safety

It is the machine manufacturer's responsibility to assess the safety risks and ensure the machine conforms to AS4024-1

CAD files

For complex shapes consisting of curves, arcs and lines, calculating points and typing lines of code can be difficult. It is easier to draw them using a CAD software package. The BACH software has an option that allows importing DXF and HPGL files produced by CAD software and converting them into motion programs. Subroutines for beginning and end of a profile (eg. tool on, tool off) can be defined and automatically inserted into the program.

Program size reduction

It is often necessary to machine a profile that consists of many interpolated lines and arcs. A typical example is the sole of a shoe. Because the shape was probably generated by CAD software, it may consist of many small straight lines joined together. The program length can be enormous, taking up valuable memory space in the RUBENS. The BACH software has an option of post processing the program and replacing a long list of linear moves with a very short list of arc moves.

Tool Radius Offset

Cutting tools remove material and therefore have a 'kerf' which must be allowed for when programming. Rewriting lines of code if the paths are circles, arcs and rectangles is easy but when paths are curves or regular shapes on an angle this can become difficult. BACH is available with an option (extra cost), allowing you to change sections of program code to compensate for tool radius offset. This uses the G40, G41 and G42 commands. When this feature is used, the program must be run from the computer using the BACH software and may not be stored in the controller. The controller is not able to do the real time processing required.

Video replay

When using servomotors, tuning the drive and RUBENS can be critical. To assist in doing this, the BACH software enables you to program a motor move and look at the response on the computer screen, graphed as coordinates and velocities with respect to time. The theoretical response can be compared to actual response. This feature is not available with stepper motors without encoders as there is no way of knowing actual position.

EMC

The RUBENS is CE marked and complies with electromagnetic compatibility standard 89/336/EEC and should be installed according to the Appendix to hardware manual "CNC1, Appendix to User's manual for S & H Controllers" It is the machine manufacturer's responsibility to ensure the machine conforms to Australian EMC Framework. Our EMC statement applies and is available on request.

Installation

We strongly recommend that a competent engineer familiar with mechanical, electrical, electronic and computer systems be involved with the installation and setup of the RUBENS controller.

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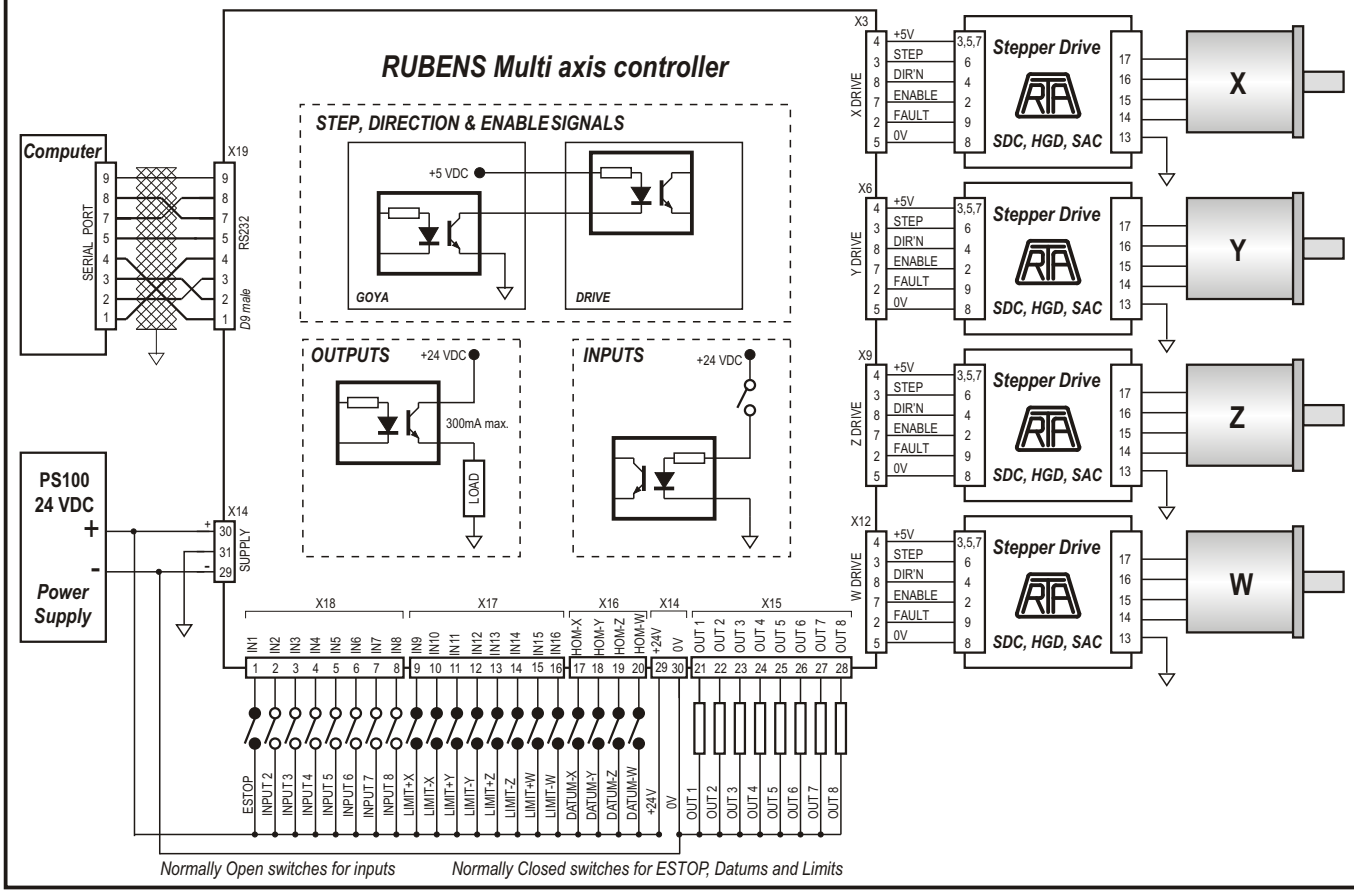
SH-RUBENS5

SUPPORTED COMMANDS

G00	Rapid move (no interpolation)
G01	Move with interpolation
G02	Clockwise circular Interpolation
G03	Anticlockwise circular Interpolation
G04	Dwell (time delay)
G06	Run axis continuously
G16	Define plane of circular interpolation
G17	Select XY plane for circular interpolation
G18	Select XZ plane for circular interpolation
G19	Select ZY plane for circular interpolation
G20	Unconditional jump
G21	Jump if flag TRUE
G22	Jump if flag FALSE
G25	Define minimum limits
G26	Define maximum limits
G27	Cancel work limits
G30	Recall subroutine
G31	Recall subroutine if flag TRUE
G32	Recall subroutine if flag FALSE
G50	Cancel displacement of origin
G51	Seek Datum switch
G52	Displacement of origin
G90	Activate absolute coordinates
G91	Activate relative coordinates
G53	Origin of axes at this point
G54	Origin of axes at this point (software set)
G55	Save current origin
G56	Restore origin set by G55
G57	Activate continuous velocity
G58	Deactivate continuous velocity
G61	Activate accurate stop
G62	Deactivate accurate stop
G63	Activate 'don't wait for end of movement'
G64	Deactivate 'don't wait for end of movement'
G65	Wait for input to go low before proceeding
G66	Wait for input to go high before proceeding
G67	Switch output OFF
G68	Switch output ON
G69	Assign state of flag
G70	Units in inches
G71	Units in millimetres
G80	Enable/Disable cam table
G81	Define DISENGAGE cam positions
G82	Define automatic cam table
G83	Define cam factor
G84	Define cam velocity variations
G94	Deactivate tangential tool guide

TYPICAL SCHEMATIC



Continuous development may necessitate changes in specifications without notice.
Motors, drives, belts & pulleys and gearheads also available.

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